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We Do Quality

Astronergy will increase capacity to 75 MW in early 2011 with plans to reach 400 MW in the near future

Astronergy Jump Starts Expansion with New Thin Film Silicon Equipment from Oerlikon Solar

Trübbach (Switzerland)/Hangzhou (China), August 9, 2010 – Astronergy and Oerlikon Solar jointly announced a follow-up purchase agreement for Oerlikon Solar's thin film equipment. With this order, Astronergy will increase its production capacity from 30 megawatts (MW) today to 75 MW in 2011. The purchase is a key element in the expansion plan of Astronergy's thin film solar photovoltaic (PV) modules of up to 400 MW within the near future. "We are committed to taking the thin film route as a direction for growth," said Dr. Liyou Yang, Astronergy CEO. "We are pleased to see that we can contribute with our technology to a continuous increase of the thin film silicon market," states Dr. Michael Buscher, CEO of Oerlikon.

As the first large-scale manufacturer of high-efficiency, tandem-junction Amorphous and Micromorph® thin film modules in mainland China, Astronergy has been able to offer its products to customers in varied regions for a wide variety of applications, including a facade at its headquarters in Hangzhou.

"By focusing our efforts on thin film products and diligently working to strengthen our core competencies, we will maintain our reputation as a firstclass PV enterprise. We are highly confident that continued collaboration will enable both of our companies to extend our leadership in the thin film solar industry," said Dr. Liyou Lang, CEO of Astronergy.

Oerlikon Solar AG, Trübbach
Hauptstrasse 1a
CH-9477 Trübbach/Switzerland

Phone +41 81 784 8000
Fax +41 81 784 6544
www.oerlikon.com/solar

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The expanded capacity will incorporate new module materials and the latest innovations in thin film technology into the production process. The agreement details an expansion plan that will bring Astronergy's total thin film module capacity to at least 75 MW by early 2011, the first phase of a 400 MW thin film expansion plan.

"We let our customers benefit from technology innovations that lead to cost reductions. By continuously doing so, we help them stay on track on their cost and technology roadmaps. Astronergy represents another milestone on our way to demonstrating that thin film silicon technology leads to the lowest module production cost per watt," said Jurg Henz, CEO of Oerlikon Solar.

For further information please contact:

Brunhilde Mauthe Manager Public Relations Oerlikon Solar Tel. +41 81 784 8040 Fax +41 81 784 6544 communications.solar@oerlikon.com	Wanshu Hu Marketing Communication Dept. Astronergy Tel. +86 571 5603 2340 pr@astronergy.com www.astronergy.com

About Astronergy
Founded in 2006, Astronergy is a trusted provider of monocrystalline and polycrystalline PV modules. It is also the first Chinese company, and one of the first companies worldwide, to bring mass production of a-Si/µc-Si thin film to the market. Astronergy has one of the most complete PV product lines in mainland China.

For more information, please visit Astronergy's website: www.astronergy.com

About Oerlikon
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Oerlikon Solar has Micromorph® patents dating back to 1993, was the first to integrate the high-efficiency Transparent Conductive Oxide (TCO) layer, and the first to commercialize the high-efficiency Micromorph® process and support the majority of its customers in migrating to it. To date it is the only proven end-to-end Micromorph® solution available on the market, offering lowest cost of electricity $/kWh, and proving highest future cost reduction potential.

Oerlikon Solar thin film silicon modules are produced with non-toxic materials, and they are ideal for semi-transparent glass and other building-integrated PV (BIPV) applications. Thin film modules perform well in diffuse or lower light, and are best suited for high temperature climates. Its production lines are complete systems, yet modular and upgradeable, so customers have the capability to scale up rapidly with the latest technology to meet fast-growing demand for solar PV, demand that will accelerate as the cost of PV energy approaches grid parity.

Oerlikon Solar is headquartered in Switzerland, has about 700 employees in 13 locations worldwide, a number of factories in production around the globe and maintains sales and service centers in the USA, Europe, China, Taiwan, Korea, Singapore and Japan.

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Hauptstrasse 1a
CH-9477 Trübbach/Switzerland

Phone +41 81 784 8000
Fax +41 81 784 6544
www.oerlikon.com/solar

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Press information / EMBARGO until 7/9/10 13:30

Oerlikon Solar introduces ahead of its technology roadmap the new production line "ThinFab"

Oerlikon Solar Breaking Two World Records: Lowest Module Production Cost and Highest Lab Cell Efficiency

Valencia (Spain), 7 September 2010 – Oerlikon Solar launched today the new production line "ThinFab" for manufacturing of thin film silicon modules, which will achieve record breaking production costs of € 0.50 per Watt peak (Wp). Furthermore, Oerlikon Solar developed a new champion Micromorph® lab cell in cooperation with Corning Incorporated with 11.9 percent stabilized efficiency confirmed by the honorable U.S. National Renewable Energy Laboratory (NREL). The two world records boost the competitiveness of Oerlikon Micromorph® thin film silicon technology and demonstrate its future potential. "Our achievements could become a breakthrough for thin film silicon technology," says Michael Buscher, Oerlikon Group CEO. "We are proud that our new ThinFab offers a highly competitive production line to the solar market and that we could verify further potential of our technology."

The new ThinFab incorporates a wide range of improvements ahead of the Oerlikon Solar technology roadmap:

- New generation of the core equipments PECVD, TCO and Laser
- Thinner cell structures with reduced degradation and reduced gas consumption
- Stabilized module efficiency of 10 percent (143 Wp per module)
- New low voltage module design, based on a simplified new backend equipment

The ThinFab reduces the energy payback-time of thin film silicon modules below one year, with the lowest energy consumption for photovoltaic production plants in the industry.

"Our extraordinary competencies are embedded in our new ThinFab and will change the perception of thin film silicon technology. The 10 percent efficiency of our non-toxic, environmentally friendly modules, combined with the lowest production costs ever, provides the solar industry with completely new opportunities. On top of that our new champion cell with 11.9 percent stabilized

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Fax +41 81 784 6544
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efficiency demonstrates even further potential of the thin film silicon technology", states Dr. Jurg Henz, Oerlikon Solar CEO. Furthermore "our technology offers the lowest energy payback time compared to other crystalline technologies and is not based on limited resources."

Oerlikon Solar's existing customers can as well benefit from many technical improvements. Oerlikon Solar will gradually introduce upgrade packages, enabling better performance, higher output, and improved efficiencies of their existing production lines.

The Oerlikon Solar ThinFab was presented to the public with the kind support of Robby Naish, who won his first windsurfing world championship in 1977 at the age of 13. Thereafter he led the world championship for 23 years in a row due to his extraordinary competencies and his innovative drive.

You will find us at the 25th European Photovoltaic Solar Energy Conference and Exhibition (EU PVSEC) in Valencia in hall 2, on level 2, booth B8.

For more detailed information about the new ThinFab visit www.oerlikon.com/solar/thinfab or contact:

Brunhilde Mauthe
Manager Public Relations
Oerlikon Solar

Tel. +41 81 784 8040
Fax +41 81 784 6544
brunhilde.mauthe@oerlikon.com

Burkhard Böndel
Head of Corporate Communications
OC Oerlikon

Tel. +41 58 360 96 02
Fax. +41 58 360 91 93
burkhard.boendel@oerlikon.com

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CH-9477 Trubbach/Switzerland

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Fax +41 81 784 6544
www.oerlikon.com/solar

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Press information

Oerlikon Solar Announces Next Key Customer Win in China

Oerlikon Solar Receives Order for 40 MW Turnkey Production Line From China

Truebbach, (Switzerland) Oct. 19, 2010 – Oerlikon Solar, the world's leading supplier of thin film silicon photovoltaic (PV) production equipment, announced its latest customer order from Hunan Gongchuang Photovoltaic Science & Technology Co. Ltd. The Hengyang City based company ordered a 40 MW Micromorph® turnkey production line, known as the FAB 1200. The production line will be in mass production by the end of 2011, producing approximately 330,000 solar modules per year.

Oerlikon Solar's customer contract with Gongchuang, which was signed in August at a Sino-Swiss conference in Beijing as part of a commemoration of 60 years of commercial ties between China and Switzerland, has now gone into effect. In attendance at the signing in August were Swiss Confederation President Doris Leuthard and Chen Deming, minister of commerce of the People's Republic of China. "We are very proud to bring Swiss engineering excellence from Oerlikon Solar to Hunan Province," said Xie Hui, president of Gongchuang.

Gongchuang ordered the turnkey line "FAB 1200", which won an award by the prestigious VLSI Research Inc. in 2009. With upgrade packages for better performance, higher output and improved efficiencies customers such as Gongchuang can also benefit from the brand new "ThinFab" production line, which Oerlikon Solar just recently launched at the 25th European Photovoltaic Solar Energy Conference and Exhibition (EU PVSEC) in Valencia.

"The combination of our ThinFab launch last month and our latest order from Gongchuang is very encouraging for the future development of our company," said Dr. Juerg Henz, CEO of

Oerlikon Solar AG, Trübbach
Hauptstrasse 1a
CH-9477 Trübbach/Switzerland

Phone +41 81 784 8000
Fax +41 81 784 6544
www.oerlikon.com/solar

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Oerlikon Solar. "It is a clear sign that Oerlikon Solar's thin film silicon technology is seen as a highly competitive, clean and sustainable solution for the PV industry."

For further information please contact:

Patrick Milo Head of Communications Oerlikon Solar Tel. +41 81 784 4960 Fax +41 81 784 6544 communications.solar@oerlikon.com	Burkhard Böndel Head of Corporate Communications OC Oerlikon Tel. +41 58 360 9602 Fax +41 58 360 9193 media@oerlikon.com

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CH-9477 Trübbach/Switzerland

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Fax +41 81 784 6544
www.oerlikon.com/solar

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Demonstrating Energy Efficient Transportation And Swiss Engineering Excellence around the World in 80 Days

Oerlikon Solar Racing Team Continues on Global Zero Emissions Race through North America

Trubbach (Switzerland), November 10, 2010 – Oerlikon Solar, the world's leading supplier of thin film silicon photovoltaic (PV) production equipment, is the main sponsor of the Oerlikon Solar Racing Team participating in the Zero Emissions Race with its Zerotracer electric vehicle. The Zero Emissions Race promotes sustainable mobility and transportation, aims to generate popular enthusiasm for the use of renewable energy sources for vehicles, and sets the highest environmental standards for the future. The competing teams will race around the globe in 80 days. After having crossed the Pacific Ocean, the teams will continue their race in Vancouver, Canada on Friday, November 12, and will head to San Francisco, Los Angeles and Austin, Texas. From there, they will pass through Mexico City and arrive in Cancun, Mexico for the United Nations Climate Change Conference.

"The goal of the race for Oerlikon Solar is to spread the message that there is progress in innovation for more efficient and sustainable mobility for the future," says Jürg Henz, CEO of Oerlikon Solar. "Powered by the electricity generated from Oerlikon Solar's innovative Swiss engineering thin film silicon solar technology, the Zerotracer is a perfect example of how electric vehicles can be fun to drive, desirable in design and sporty in performance, all while fighting global warming."

Mobility with zero emissions

The Zero Emissions Race is the brainchild of Louis Palmer, the first person to circle the globe in a solar-powered vehicle. Palmer's aim with the Zero Emissions Race, which is being held under the auspices of the United Nations Environmental Program (UNEP), is to present emissions-free mobility solutions. The Zerotracer, sponsored by Oerlikon Solar under the auspices of Cleantech Switzerland, is one of these solutions. The Zero Emissions Race began on August 16, 2010 at the United Nations

Oerlikon Solar AG, Trubbach
Hauptstrasse 1a
CH-9477 Trubbach/Switzerland

Phone +41 81 784 8000
Fax +41 81 784 6544
www.oerlikon.com/solar

office in Geneva and continues for 80 days, heading eastward through 16 countries and passing through more than 150 cities, including Berlin, Munich, Moscow, Shanghai, Vancouver, Los Angeles, Cancun (World Climate Conference), Lisbon and Madrid. It will conclude on January 22, 2011 in Geneva.

Before setting out to cross the Pacific Ocean, the Zerotracer arrived in Shanghai according to the original schedule, leading the race with 165 points out of 190, ahead of Germany and Australia. So far, the team has won several individual competitions for reliability, acceleration and top speeds. In North America, the teams will continue to compete and be evaluated for vehicle reliability, energy efficiency, utility to everyday life, and design and safety. Meanwhile, the South Korean team has dropped out of the race due to technical difficulties.

As the main sponsor of the Swiss team, Oerlikon Solar is responsible for generating the environmentally friendly solar energy. This energy is produced on thin film silicon modules produced with non-toxic materials, and powers the Zerotracer at 2,400 kilowatts/hour (kWh) for the 30,000 kilometres (km) trip around the world. The Zerotracer is the product of a four-man team of young engineers and designers who work with such vehicles in order to fashion new mobility concepts for tomorrow. Oerlikon Solar and the team are both pioneering work in the area of environmentally sustainable thin film silicon solar technology, and in the future mobility with zero carbon dioxide emissions.

With its streamlined, futuristic shape, the Zerotracer is a combination of a car and a motorcycle. The core concept of the Zerotracer is to achieve ultimate efficiency with a unique driving experience, wrapped together in an attractive design package. Due to its superior aerodynamics and highly efficient electric drive train, the Zerotracer is able to accelerate faster than a Porsche 911. It has room for two people, and can hold its own against the world's fastest cars with acceleration from 0 to 100 km/h in 4.5 seconds. The Zerotracer consumes 4 kW when travelling at an average speed of 80 km/h, resulting in a range of 450 km. The body weighs less than 80 kg and is made from Kevlar composite, which is also used in Formula 1 automobile construction.

Oerlikon Solar AG, Trubbach
Hauptstrasse 1a
CH-9477 Trubbach/Switzerland

Phone +41 81 784 8000
Fax +41 81 784 6544
www.oerlikon.com/solar

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"Swiss engineering excellence"

In addition to the concept of zero emissions, Oerlikon Solar is committed to Swiss engineering excellence. The Zerotracer is a demonstration of Swiss engineering ingenuity and communicates the "High tech made in Switzerland" message around the world. As the main sponsor, Oerlikon Solar makes a significant contribution to this message with environmentally sustainable thin film silicon technology from Switzerland. Technology partners Oerlikon Mechatronics supplied tailored gearbox components and Oerlikon Graziano supplied a high-torque drive system. The electric motors, gearwheels and additional components originated from Swiss technology enterprises.

"Our objective in being part of this effort is to demonstrate that a new form of mobility based on solar energy is not only possible, but in fact already suitable for everyday use," says Henz.

For more information about the Zerotracer, when and where the car comes to a city near you and Oerlikon Solar's participation in the Zero Emissions Race please visit www.zerotracer.com, www.zero-race.com or contact the below.

Patrick Milo Head of Communications Oerlikon Solar Tel. +41 81 784 8040 Fax +41 81 784 6544 communications.solar@oerlikon.com	Louis Palmer Tour Director Zero Emission Race Tel. +41 79 343 88 01 louis.palmer@zero-race.com
Jennifer Lopez Edelman for Oerlikon Solar Tel. 650-762-2906 jennifer.lopez@edelman.com	

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Table of contents: Innovation investment helps create the thin-film ecosystem of opportunity by supplementing the R&D spend of the companies most likely to benefit from it.

Reducing Costs in PV Manufacturing

Why less is more: how thin-film manufacturing is finding momentum

Chris O'Brien, Oerlikon Solar, Trübbach, Switzerland

DECK: A new generation of thin-film silicon technology is regaining cost and performance leadership with key innovations helping to drive down cost and increase energy output and reliability to make solar power competitive.

Cost reduction is the key objective of the photovoltaics (PV) industry as it strives to position solar power as a low-cost choice for new energy capacity. Three years ago, silicon wafer prices were high and PV modules were in short supply. With crystalline silicon cells making up ~80% [1] of the PV energy capacity produced annually, fluctuations in supply and cost of polysilicon [2] in recent years created a window of opportunity for thin film technology innovation, driven by manufacturing equipment suppliers seeking new high-growth business opportunities and and by module manufacturers looking for ways to diversify and/or enter a fast-growing world PV market. Within a short period, many existing and new PV manufacturers began choosing thin-film silicon technology to reduce their strategic dependence on polysilicon and to capitalize on new innovations in thin film technologies promising an advantageous manufacturing cost.

Then the world PV market changed in 2009. Today, silicon wafers and PV modules are in more ample supply, and negotiating power has shifted back to the buyer, though the near term outlook for c-Si components is somewhat uncertain because of accelerating demand. With cost leadership now a matter of survival in a tight PV market, the competitiveness of thin-film technologies has been challenged. However a new generation of thin-film silicon technology is poised to regain cost leadership within the industry. Key innovations are helping to drive down cost and increase efficiency and reliability to reinforce thin film's competitive advantages in end user markets.

The fundamental advantages of thin-film silicon have not changed. Thin-film silicon PV modules require far less silicon than traditional methods (less than 1/100th of a wafer thickness) and use widely available, comparatively inexpensive materials. Thin-film silicon technology is inherently suitable for achieving very low manufacturing cost because the entire manufacturing process from bare glass to a complete PV module requires significantly fewer manufacturing steps than conventional crystalline technologies. Another key positive factor is that thin-film silicon technology uses only environmentally friendly, non-toxic substances. Finally, thin-film silicon panels have an inherent advantage in real energy performance, due primarily to the fact that thin-film silicon has a temperature coefficient "penalty" that is almost 50% lower than most

conventional crystalline. In hot climates, this advantage results in 5% to10% higher output per installed watt compared to crystalline silicon.

We recently announced that our Thin Fab manufacturing line design has improved productivity, reducing the expected cost of production to € 0.50/Wp and at the same time, a 100% increase in the output capacity and a 50% reduction in the capex per Watt. Together with improved stabilized lab cell efficiency of 11.9% for our Micromorph technology and a 10% stabilized module efficiency, these achievements are the result of innovations in cell and module design, equipment and facilities, silicon and TCO depositions, laser tools, and materials. Each of these is discussed below.

Thin-film cell/module design innovation

The efficiency of Micromorph cells and modules is the result of a combination of interrelated design innovations that significantly lower manufacturing costs. Improved transparent conductive oxide glass-coating (TCO) increases the transmissivity of the front glass and also enhances light scattering, increasing light capture (**Fig. 1**). Thinner amorphous and microcrystalline silicon "absorber layers" increase stabilized efficiency while reducing material costs and increasing manufacturing throughput. Finally, a new highly reflective white lamination foil enhances light capture and efficiency by reflecting photons back into the absorber layers of the cell. Figure 2 illustrates the dramatic improvement in reflectance that is achieved by using a white lamination foil instead of a layer of white paint. The introduction of a white lamination foil also helped to accelerate manufacturing productivity, as previously two manufacturing steps (applying white paint, then adding a transparent lamination foil) were replaced by one simpler manufacturing step (applying a white lamination foil). The combined effect of all of these improvements is a dramatically lowered production cost, now estimated to be €0.50/W with the new equipment. Also, the capital expenditure for Watt-peak power (W_p) is significantly reduced, largely as a result of increased equipment productivity. Finally, these changes have improved module performance with the new design yielding an expected production average module efficiency of 10% (stabilized). This new efficiency standard for thin film silicon will result in additional cost savings for installed PV systems.

Equipment and facility innovation

In addition to cell and module improvements, new advances in manufacturing equipment and manufacturing processes also play a critical role in reducing the cost of thin film silicon technology. Over the past year there has been significant progress in accelerating throughput and increasing expected reliability and yield for several key manufacturing tools used in the production of Micromorph thin film silicon panels.

Silicon deposition. A new design for silicon-deposition PECVD tool, the KAI MT, was announced earlier in 2010. This tool builds on a well-proven KAI design, including a high-frequency 40MHz Plasmabox reactor design that enables comparatively faster and uniform silicon deposition. The new KAI MT design incorporates two significant changes that result in increased capacity and reduced footprint. First, the new design incorporates three deposition chambers per KAI tool, with each deposition chamber capable of handling 10 modules at a time. The new configuration can be seen in Figure 3a, where "PM" refers to deposition chambers. Previously the KAI had just two deposition chambers per tool. This new design provides a 50%

increased glass coating area and throughput, with no significant increase in equipment cost. Productivity is further enhanced by a modification in the silicon deposition itself, whereby both the a-Si top cell and the microcrystalline bottom cell are deposited in the same KAI chamber, eliminating the need to expose the glass to atmosphere in between deposition processes and improving overall deposition speed and quality. Finally, the configuration of the deposition tools has been made significantly more compact by shifting the location of auxiliary equipment (e.g. vacuum pumps) to a mezzanine above the KAI MT, resulting in a 50% reduction in footprint (see Figure 3b).

TCO deposition. A second example of significant equipment performance and production cost improvements is seen with the equipment used for deposition of "transparent conducting oxide" (TCO). This deposition is done in a low-pressure chemical vapor deposition (LPCVD) process and toolset. The integration of this TCO deposition tool into the thin film silicon manufacturing process allows for two key advantages over the use of pre-coated glass. First, on-site TCO deposition allows for the use of zinc oxide (ZnO) for the TCO layer, a material that yields a significantly higher performance than commercially-coated glass (which uses tin-oxide). Second, including the TCO deposition tool in the thin film silicon manufacturing line allows for optimization of the interface between the TCO and silicon absorber layers, resulting in enhanced light scattering, which results in increased light capture and higher module efficiency. . Furthermore, the integration of TCO deposition into the thin film silicon manufacturing line allows manufacturers to use plain uncoated glass as a feedstock, resulting in a cost savings of €10 per panel or more compared with the cost of using pre-coated glass.

The most current version of Oerlikon Solar's TCO deposition tool (an integral component of the company's ThinFab manufacturing line design), incorporates several significant improvements. For example, optimized shields allow significantly stretched cleaning intervals. the deposition rate has been improved substantially' and the back transport of the glass has been changed for easier maintenance. As a result, the tool achieves higher uptime and throughput in the field.

Laser tool. The third example of "core" manufacturing equipment used in the production of thin film silicon PV modules is the laser tool, used to sculpt the thin film silicon and TCO layer stacks to form interconnected PV cells. Two key laser performance parameters that help to drive down production cost are the laser accuracy and the laser tool's processing speed / throughout. Improved laser accuracy results in a reduced "dead zone" between cells resulting from laser scribes. Figures 4a and 4b show the dramatic progress that has been made in this area by Oerlikon Solar to reduce the losses resulting from laser scribing processes in its most recent ThinFab design. The laser tools included in this manufacturing line are now capable of producing Micromorph modules with a dead zone of approximately 200µm, roughly half of the dead zone thickness that was typical for production just two years ago (and that is still typical for many thin film module manufacturers today). The result is a reduction in the area loss within the module and higher module power. Furthermore, Oerlikon Solar's newest laser tool (LSS) has doubled the number of laser heads, resulting in a 100% increase in throughput compared with previous generation tools, with increased reliability and uptime.

In sum, the changes outlined above to the "core" manufacturing equipment tools have resulted in substantially increased performance and productivity with 1) a more than 50% throughput

increase, 2) a more than 50% module cost reduction, 3) a 100% increase in output capacity, and 4) overall fab line yields of ~97%.

Materials innovation

In thin-film silicon manufacturing, materials (e.g., glass, lamination foil, junction box, etc.) represent over 50% of the total cost of a thin-film silicon PV module. Reduction in the amount and price of key materials is a major factor in driving down the total cost of module production. Technology providers can greatly reduce the expected cost of module manufacturing by optimizing the design of the module itself, while aggressively working with suppliers of key materials to qualify several competing vendors of key materials for the modules. We have achieved a 50% reduction of material cost over the last three years, thanks in part to qualification of new suppliers and optimizing the minimum requirement specifications. In addition to the white lamination foil example described above, other significant material cost reductions have been achieved in the junction box, contacts, encapsulants, and the front glass.

Thin-film manufacturing equipment leaders are demonstrating tremendous potential to accelerate the pace of PV performance improvements and cost reductions, helping to position thin film silicon PV manufacturers to be competitive with other PV industry cost leaders, helping to make solar power economically viable.

Acknowledgment

Micromorph and Plasmabox are trademarks of Oerlikon Solar.

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Biography

Chris O'Brien received his A.B. and B.E degrees from Dartmouth College, and his M.B.A. from Stanford University and is Head of Market Development, Oerlikon Solar, Trübbach, Switzerland. Chris is based in Washington, DC - 700 12th Street NW, Suite 700, Washington, DC 20005; ph.: 205-558-5177; email chris.obrien@oerlikon.com.

List of figures and tables

Figure 1. Transmittance of Oerlikon Solar's TCO on white glass compared with other TCO alternatives and glass types.

Figure 2. Comparison of white foil lamination to white paint.

Figure 3a and 3b. Layout of KAI MT vacuum deposition tool for Micromorph

Figure 4. a) Comparison of laser design changes on dead zone width; and b) dead zone reduction track record. Source: Oerlikon Solar [AWAITING TECHNICAL PAPER CITATION]